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HFDM03 Test Summary

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1. Introduction

HFDM03 is a mirror magnet made from newly wound and cured Nb3Sn cable (see construction report) which was made of the famous PIT 1mm strand. The magnet was completed on March 18th, 2004. After it was installed into the VMTF dewar it was electrically checked out by April 6th , 2003. The VMTF dewar was filled with liquid helium on April 12th, 2004. This magnet went trough only one test cycle which has been completed on April 16th. On April 23rd 2004 the magnet was at room temperature.

2. Quench History and Quench Locations

The first quench of the magnet was at much higher current value (16233A) than any other cosine theta dipoles, and it was about 78% of the critical current value calculated on the basis of short sample critical current measurements. The magnet exhibited slow but pretty steady training. It took only 20 quenches to reach its critical current limit value. After reaching the quench plateau we continued the test program with ramp rate dependence studies. In order to confirm that the magnet reached its critical current value the magnet was cooled down to 2.2K. Quench behavior at 2.2 K was quite erratic. It seems that the magnet exhibited similar performance as what we have seen with other cosine theta magnets at 4.5K. On the other hand we were able to expose the magnet to higher Lorentz forces that it was achieved at 4.5K. The quench program was completed with taking few quenches again at 4.5K confirming that the magnet quench current is in the same range than it was prior to 2.2 K quenching. The quench summary is shown in Fig 1. and the details are described in Table 1.

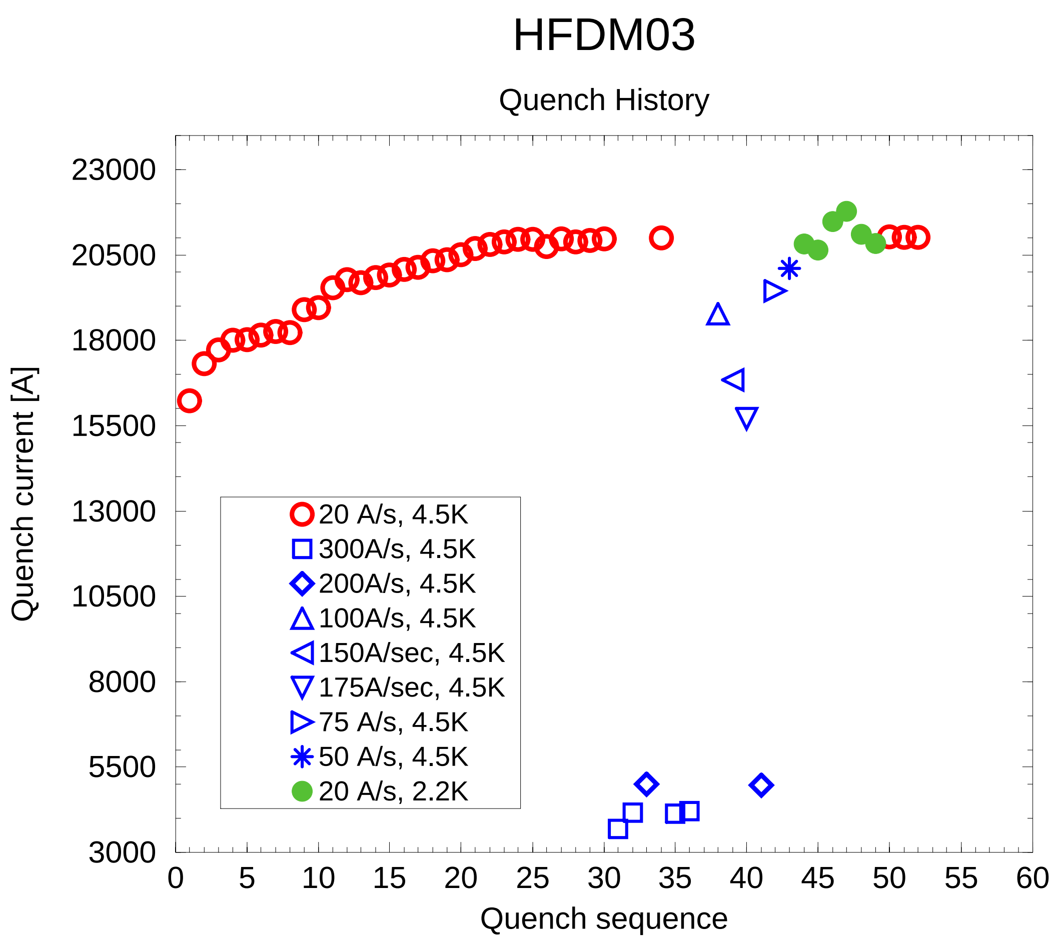


Fig. 1. Quench history of HFDM03 is shown.

Table 1. Quench summary details.

File	Quench No.	Current	dIdt	tquench	MIITs	QDC	1st VTseg	trise	CgDeMaBotL_1
hfdm03.Quench.040412165811.369	1	16233	20	-0.0098	10.68	HcoilHcoil	Q19au_QC9c	-0.0097	4.526
hfdm03.Quench.040413141506.437	2	17317	20	-0.0049	10.60	HcoilHcoil	Q19au_QC9c	-0.0031	4.435
hfdm03.Quench.040413145654.079	3	17722	20	-0.0028	10.30	HcoilHcoil	Q19au_QC9c	-0.0018	4.439
hfdm03.Quench.040413152122.869	4	18002	20	-0.0024	10.41	HcoilHcoil	Q19au_QC9c	0.0010	4.438
hfdm03.Quench.040413154454.499	5	18018	20	-0.0048	11.19	HcoilHcoil	Q19au_QC9c	-0.0045	4.438
hfdm03.Quench.040413160905.901	6	18148	20	-0.0032	10.77	HcoilHcoil	Q19au_QC9c	-0.0038	4.446
hfdm03.Quench.040413163459.986	7	18265	20	-0.0032	10.91	HcoilHcoil	Q19au_QC9c	-0.0014	4.445
hfdm03.Quench.040413170020.358	8	18225	20	-0.0195	16.26	HcoilHcoil	Q19au_QC9c	-0.0148	4.445
hfdm03.Quench.040413172512.835	9	18898	20	-0.0020	11.10	HcoilHcoil	Q19au_QC9c	-0.0013	4.449
hfdm03.Quench.040413175656.036	10	18958	19	-0.0031	11.53	HcoilHcoil	Q19au_QC9c	-0.0010	4.444
hfdm03.Quench.040413182301.266	11	19540	21	-0.0013	11.43	HcoilHcoil	Q19au_QC9c	-0.0010	4.447
hfdm03.Quench.040413184831.210	12	19775	20	-0.0029	12.21	HcoilHcoil	Q19au_QC9c	-0.0022	4.448
hfdm03.Quench.040413191626.200	13	19697	20	-0.0021	11.91	HcoilHcoil	Q19au_QC9c	0.0000	4.438
hfdm03.Quench.040413194057.969	14	19844	20	-0.0022	12.05	HcoilHcoil	Q19au_QC9c	-0.0003	4.446
hfdm03.Quench.040413200617.378	15	19910	19	-0.0021	12.03	HcoilHcoil	Q19au_QC9c	-0.0013	4.444
hfdm03.Quench.040413211349.806	16	20075	20	-0.0022	12.24	WcoilIdot	Q19au_QC9c	-0.0013	4.435
hfdm03.Quench.040413213652.940	17	20137	20	-0.0017	12.12	HcoilHcoil	QC9c_QOS2	0.0010	4.443
hfdm03.Quench.040414082821.940	18	20333	20	-0.0015	12.16	HcoilHcoil	Q19au_QC9c	-0.0006	4.449
hfdm03.Quench.040414085238.571	19	20360	20	-0.0083	15.28	HcoilHcoil	Q14au_Q19au	0.0024	4.446
hfdm03.Quench.040414091831.826	20	20514	20	-0.0020	12.53	HcoilHcoil	Q19au_QC9c	-0.0008	4.443
hfdm03.Quench.040414094229.007	21	20685	20	-0.0020	12.53	WcoilIdot	Q19au_QC9c	0.0003	4.455
hfdm03.Quench.040414100646.513	22	20803	19	-0.0025	13.00	HcoilHcoil	Q19au_QC9c	0.0006	4.465
hfdm03.Quench.040414103320.872	23	20878	20	-0.0011	12.45	HcoilHcoil	Q19au_QC9c	-0.0001	4.483
hfdm03.Quench.040414110311.019	24	20964	20	-0.0014	12.58	HcoilHcoil	Q19au_QC9c	0.0003	4.499
hfdm03.Quench.040414112725.707	25	20953	20	-0.0013	12.45	HcoilHcoil	Q19au_QC9c	-0.0003	4.524
hfdm03.Quench.040414114810.233	26	20746	20	-0.0025	12.87	HcoilHcoil	Q19au_QC9c	-0.0006	4.540
hfdm03.Quench.040414131009.864	27	20976	20	-0.0007	12.27	HcoilHcoil	Q19au_QC9c	0.0000	4.518
hfdm03.Quench.040414133740.118	28	20888	20	-0.0018	12.67	HcoilHcoil	Q19au_QC9c	0.0006	4.531

hfdm03.Quench.040414140459.674	29	20936	20	-0.0011	12.44	HcoilHcoil	Q19au_QC9c	0.0006	4.529
hfdm03.Quench.040414145950.730	30	20972	20	-0.0014	12.57	HcoilHcoil	Q19au_QC9c	0.0000	4.517
hfdm03.Quench.040414152245.802	31	3685	300	-0.0721	1.48	HcoilHcoil	QC9c_QOS2	-0.0101	4.508
hfdm03.Quench.040414153622.576	32	4182	287	-0.0598	1.66	HcoilHcoil	QC9c_QOS2	-0.0010	4.505
hfdm03.Quench.040414154412.861	33	5029	199	-0.0434	1.96	WcoilIdot	QC9c_QOS2	0.0022	4.505
hfdm03.Quench.040414160946.871	34	20997	20	-0.0008	12.35	HcoilHcoil	Q19au_QC9c	0.0004	4.511
hfdm03.Quench.040414161824.801	35	4177	286	-0.0603	1.66	WcoilIdot	QC9c_QOS2	0.0014	4.526
hfdm03.Quench.040414163201.176	36	4244	289	-0.0634	1.78	HcoilHcoil	QC9c_QOS2	-0.0011	4.509
hfdm03.Quench.040414165920.045	37	18777	100	-0.0017	10.62	HcoilHcoil	Q19au_QC9c	0.0003	4.502
hfdm03.Quench.040414170737.213	38	16847	151	-0.0018	8.92	WcoilIdot	Q19au_QC9c	0.0011	4.515
hfdm03.Quench.040414171819.994	39	15713	176	-0.0032	8.21	WcoilIdot	Q14au_Q19au	-0.0013	4.510
hfdm03.Quench.040414173005.872	40	4970	199	-0.0462	2.01	WcoilIdot	QC9c_QOS2	0.0032	4.506
hfdm03.Quench.040414174424.219	41	19452	76	-0.0014	11.19	HcoilHcoil	Q19au_QC9c	0.0001	4.506
hfdm03.Quench.040414175743.933	42	20104	50	-0.0013	11.70	HcoilHcoil	Q19au_QC9c	0.0000	4.515
hfdm03.Quench.040415160741.622	43	20826	20	-0.0020	12.98	WcoilIdot	Q19au_QC9c	0.0013	2.153
hfdm03.Quench.040415162928.220	44	20649	20	-0.0021	12.88	HcoilHcoil	Q19au_QC9c	-0.0007	2.153
hfdm03.Quench.040415165232.905	45	21484	20	-0.0028	13.96	HcoilHcoil	Q19au_QC9c	0.0004	2.153
hfdm03.Quench.040415172525.967	46	21777	19	-0.0013	13.38	HcoilHcoil	Q19au_QC9c	0.0001	2.152
hfdm03.Quench.040415174715.414	47	21103	20	-0.0014	13.00	HcoilHcoil	Q19au_QC9c	0.0008	2.153
hfdm03.Quench.040415181059.464	48	20840	20	-0.0025	13.18	HcoilHcoil	Q19au_QC9c	0.0006	2.152
hfdm03.Quench.040416102032.217	49	21031	20	-0.0013	12.61	HcoilHcoil	Q19au_QC9c	0.0003	4.450
hfdm03.Quench.040416104914.934	50	21019	20	-0.0013	12.56	HcoilHcoil	Q19au_QC9c	0.0001	4.481
hfdm03.Quench.040416112406.007	51	21016	20	-0.0014	12.58	HcoilHcoil	Q19au_QC9c	0.0003	4.476

This magnet behaved differently than any other cosine theta magnets. The quench locations were inside the body of the magnet. Some of the quenches might have started close to a voltage tap Q19au since two segments were quenched about the same time (see Fig 2). On the other hand a third, not adjacent segment quenched as well, which means that these quenches might be independent from each other so we can only conclude which segment quenched and we can’t localize them further.

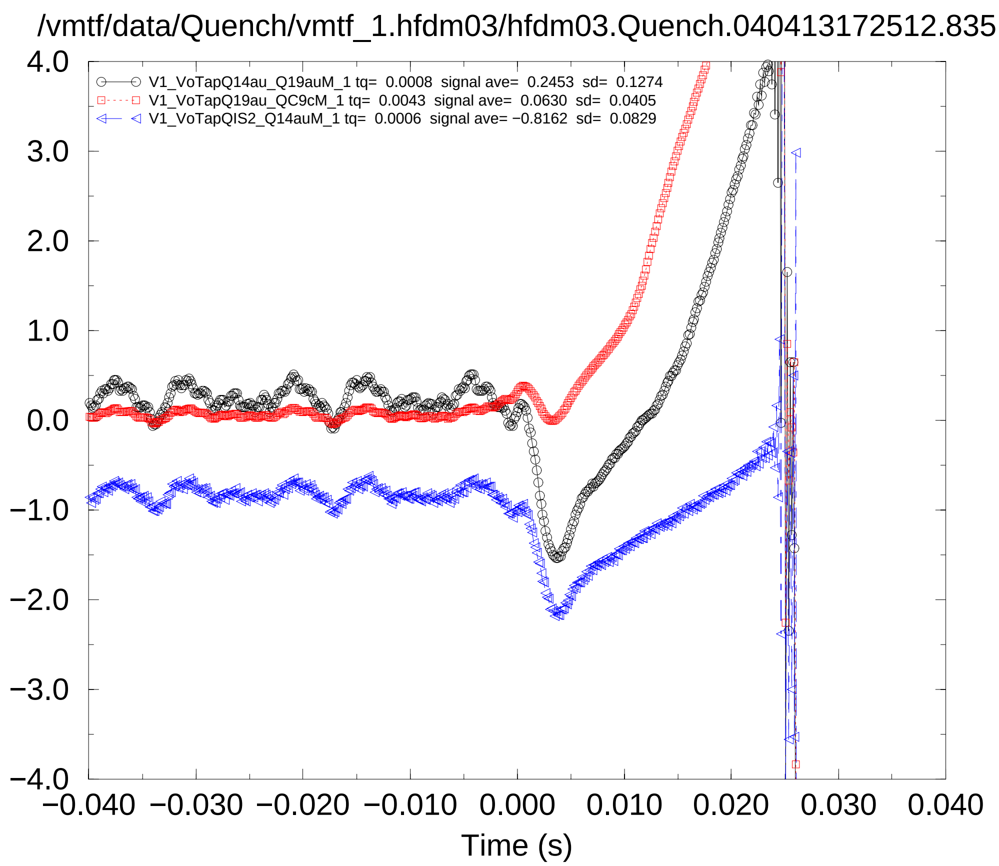


Fig 2. Voltage traces for quench number 9. Three voltage segment exhibited positive signals within 10 ms time interval. Quench started in Q19au_QC9c segment.

3. Ramp Rate Dependence

Ramp rate dependence is shown in Fig 3. Quench current decreases with increasing ramp rate following a continuous function. This behavior is a good indication that the magnet is at critical current limit. At ~180 A/s ramp rate there is a sudden drastic change in this smooth current ramp rate dependence. This behavior might be explained with hysteretic losses combined with cooling conditions.

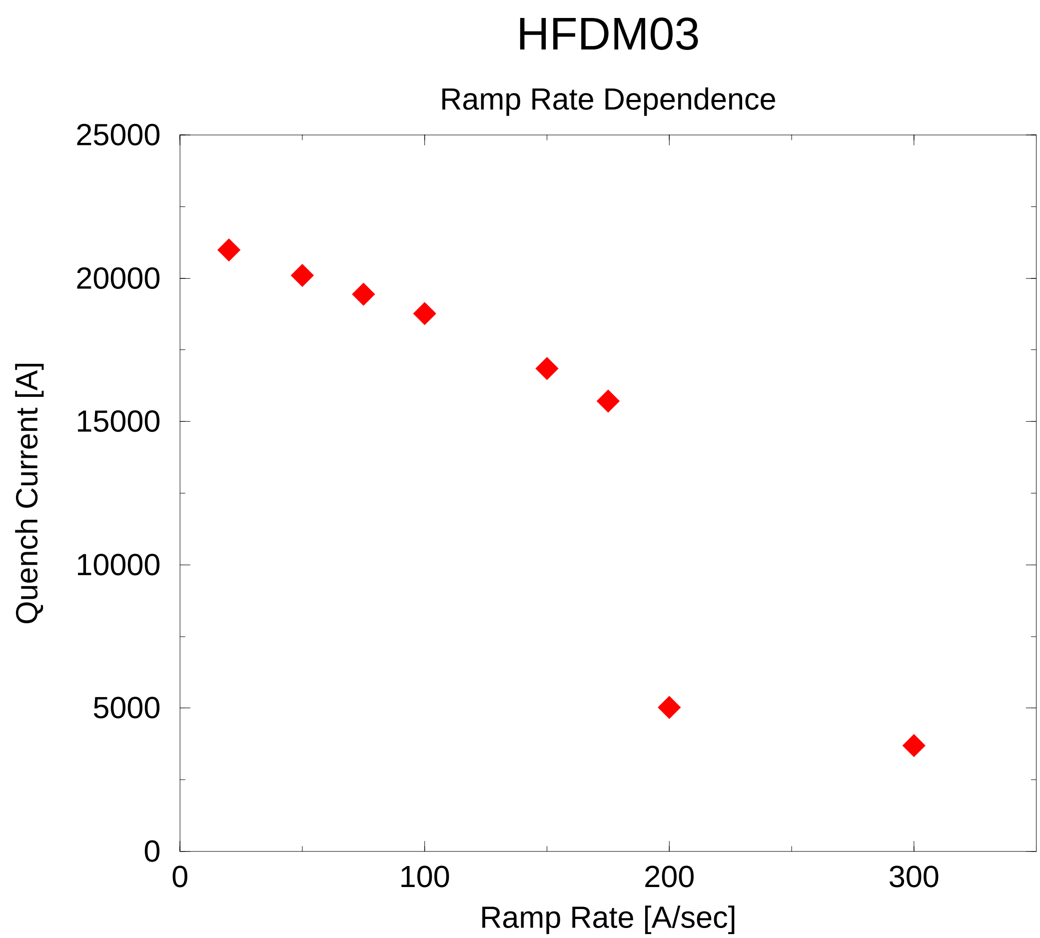
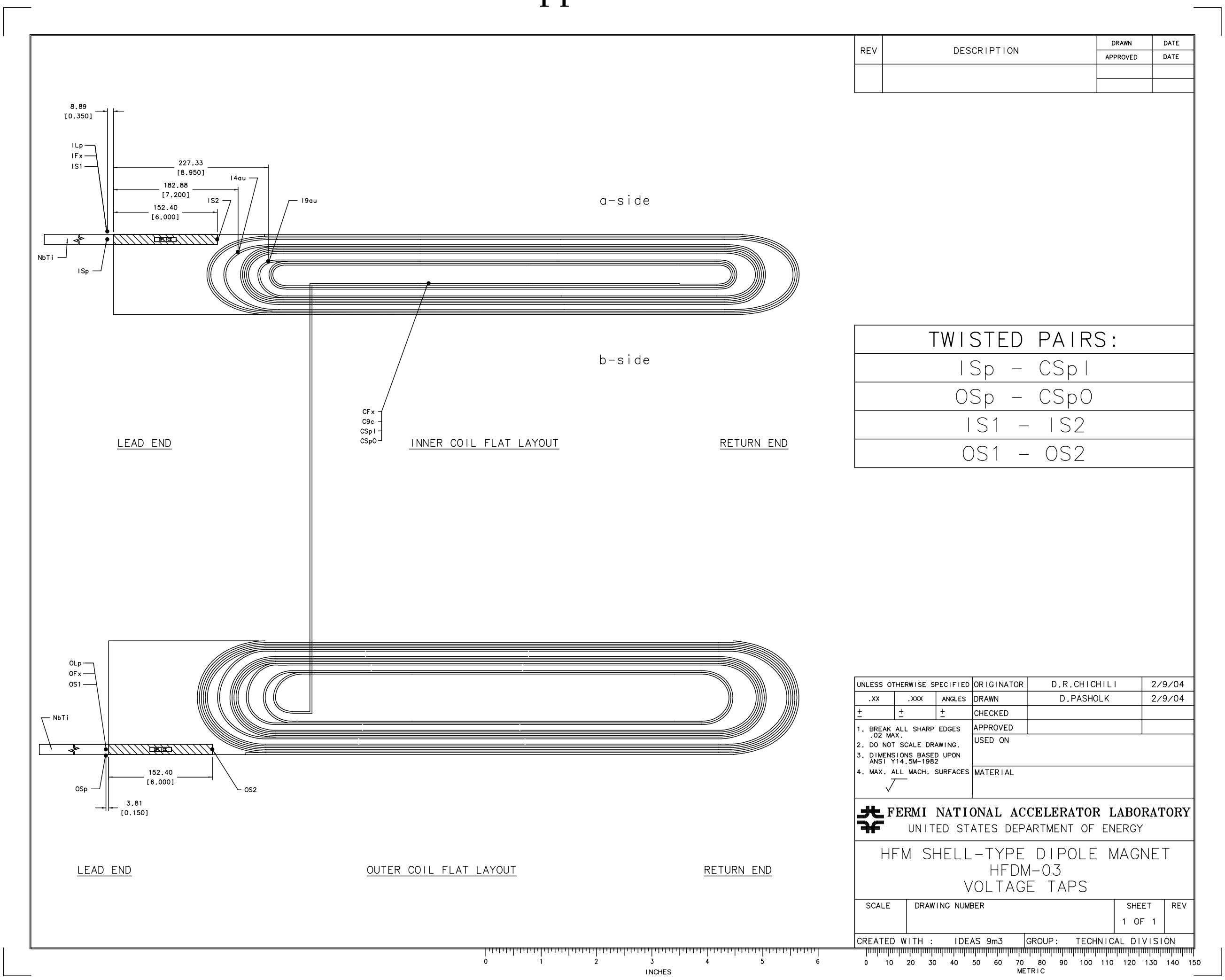


Fig 3. Quench current ramp rate dependence.

5. RRR measurements

After the cold test was completed the magnet was gradually warmed up. We used this opportunity to measure the magnet voltages under small current (± 10A) values as a function of the magnet temperature. The obtained RRR value is 84. The transition temperature of the magnet was at 18.2K ± 0.5K.

6. Appendix



Voltage tap layout